

# A DISK DRIVE COMPRISING A COVER SHAPED TO IMPROVE RADIAL AND AXIAL SHROUDING

## **BACKGROUND OF THE INVENTION**

## **Field of the Invention**

The present invention relates to disk drives for computer systems. More particularly, the present invention relates to a disk drive with improved shrouding.

## **Description of the Prior Art**

A computer system usually includes one or more disk drives for economical, non-volatile data storage. FIG. 1 shows a typical prior art disk drive 100 which includes a housing formed by fitting a cover comprising an inner layer 102 and an outer layer 104 to a base 106 to create a sealed head disk assembly (HDA) chamber. The HDA includes one or more disks 108 stacked in a spaced-apart relationship on a spindle motor hub and rotated by a spindle motor (not shown). The disks 108 rotate in close proximity to a head 114 that is disposed by means of a head gimbal assembly (HGA) attached to one of a plurality of actuator arms 110.

17 The spindle motor includes a stationary element such as a fixed spindle shaft 116 affixed  
18 to the disk drive housing at the base and cover to define and stabilize a spindle axis about which  
19 a hub rotates the disks 108. A stator of the spindle motor, as well as bearings and seals, are  
20 secured between the fixed spindle shaft 116 and the rotating hub. The actuator arms 110 are part  
21 of a head stack assembly (HSA) that turns about a pivot bearing assembly by a voice coil motor  
22 (VCM) 112. The pivot bearing assembly includes a stationary element such as a pivot shaft that  
23 is fixed to the disk drive housing at the base and cover to define and stabilize a pivot axis for the  
24 HSA. Typically, the pivot shaft is rigidly coupled at the top to the cover and at the bottom to the  
25 base. The rigid attachment of the fixed spindle shaft and the pivot shaft fixes and stabilizes the  
26 relationship of the spindle axis and the pivot axis to control head positioning error. The actuator  
27 arms 110 move in response to energizing currents sent to the voice coil motor (VCM) 112 which

1 moves the HSA on the pivot axis, swinging the actuator 110 arms to move the associated heads  
2 114 over the associated disk surfaces.

3 It is desirable to transfer data to and from disks 108 rapidly. The data transfer rate  
4 increases with spindle motor rotational speed. However, there are a number of problems  
5 associated with higher spindle motor rotational speeds. One problem is increased internal air  
6 turbulence in the HDA which can excite disk flutter modes, thereby setting up resonances that  
7 can cause the heads 114 to move off track during read and write operations. Proper centerline  
8 tracking is imperative for faithfully writing data to, and reading data from, the disks 108.  
9 Another problem associated with higher spindle motor rotational speeds is increased windage  
10 drag on the disks, thereby causing an increase in spindle motor current and elevated internal  
11 HDA temperature. Yet another problem associated with higher spindle motor rotational speeds  
12 is an increase in the acoustic noise radiated by the disk drive.

13 Shrouding the disks 108 can reduce internal air turbulence thereby attenuating disk  
14 flutter, windage drag, and acoustic noise. The prior art disk drive of FIG. 1 provides radial  
15 shrouding by molding the base 106 into a cylindrical form such that the disk 108 fits snugly  
16 within, leaving a very narrow gap between the spinning outer perimeter of the disks 108 and the  
17 inner surface of base 106. However, the radial shroud of the base 106 cannot extend into the gap  
18 118 coextensive with the actuator arms 110 so that the HSA can be inserted into the base 106  
19 during manufacture. When inserting the HSA, the actuator arms 110 are rotated such that they fit  
20 into the gap 118 without damaging the heads 114. The actuator arms 110 are then rotated to  
21 position the heads 114 over the disks 106. The air turbulence which forms in this gap 118  
22 exacerbates the disk flutter, windage drag, and acoustic noise.

23 U.S. Patent 5,898,545 to Schirle discloses a separate shroud piece which is inserted into  
24 the gap 118 and connected to the base 106 after installing the HSA. The separate shroud piece  
25 comprises air flow vanes and cams to facilitate "ramp loading" the heads 114 during spin down.  
26 Although the separate shroud piece improves the shrouding over the prior art disk drive 100 of  
27 FIG. 1, it must be precisely machined and then precisely mounted into the base 106 in both the

1 axial and radial directions with respect to the disks 108 so as to protrude onto the disks 108 the  
2 correct distance. These precision manufacturing constraints increase the complexity and cost of  
3 the disk drive.

4 There is, therefore, a need to improve shrouding within a disk drive without incurring the  
5 complexity and expense of precisely machining and precisely installing additional components.

6 **SUMMARY OF THE INVENTION**

7 The present invention may be regarded as a disk drive with improved shrouding,  
8 comprising a disk, a spindle motor for rotating the disk, a head, an actuator arm for actuating the  
9 head radially over the disk, a base, and a cover attached to the base to form a head disk assembly  
10 chamber. The cover comprises an inner surface and an outer surface, and a shroud extending  
11 axially from the inner surface into the head disk assembly chamber substantially enveloping the  
12 periphery of the disk, including at least part of the periphery coextensive with the actuator arm,  
13 to provide radial shrouding of the disk.

14 In one embodiment, the cover further comprises a substantially C-shaped depression  
15 positioned substantially concentric over the disk to provide axial shrouding.

16 The present invention may be regarded as a method of manufacturing a disk drive with  
17 improved shrouding. A shroud is formed in a cover of a head disk assembly (HDA). A disk, a  
18 head, an actuator arm for actuating the head radially over the disk, and a motor for rotating the  
19 disk, are disposed into the HDA. The cover is attached to a base of the HDA such that the  
20 shroud substantially envelops the periphery of the disk, including at least part of the periphery  
21 coextensive with the actuator arm, to provide radial shrouding of the disk.

22 In one embodiment, the method of manufacturing the disk drive further comprises the  
23 step of forming a substantially C-shaped depression in the cover, the C-shaped depression  
24 positioned substantially concentric over the disk to provide axial shrouding.

25 **BRIEF DESCRIPTION OF THE DRAWINGS**

26 FIG. 1 shows a prior art disk drive wherein the base of a head disk assembly (HDA) is  
27 formed around the periphery of the disk to provide radial shrouding, but does not extend into a

1 gap which facilitates installing the head stack assembly into the HDA during manufacturing.

2 FIG. 2 shows a disk drive according to an embodiment of the present invention  
3 comprising a head disk assembly (HDA) chamber for housing a head stack assembly and a disk.  
4 An HDA cover comprises an inner surface and an outer surface, and a shroud extending axially  
5 from the inner surface into the HDA chamber substantially enveloping the periphery of the disk,  
6 including at least part of the periphery coextensive with an actuator arm, to provide radial  
7 shrouding of the disk.

8 FIG. 3A shows further details of the shroud integrated with the cover of FIG. 2.

9 FIG. 3B shows a cover for an HDA according to an alternative embodiment of the present  
10 invention, wherein the cover comprises a substantially C-shaped depression positioned  
11 substantially concentric over the disk to provide axial shrouding of the disk.

12 FIG. 4 shows a cover for an HDA according to an alternative embodiment of the present  
13 invention comprising an inner layer and an outer layer, wherein the inner layer comprises a  
14 substantially C-shaped depression positioned substantially concentric over the disk to provide  
15 axial shrouding of the disk.

## 16 **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

17 FIG. 2 shows a disk drive 120 according to an embodiment of the present invention  
18 comprising a disk 122, a spindle motor for rotating the disk 122, a head 124, an actuator arm 126  
19 for actuating the head 124 radially over the disk 122, a base 128, and a cover 130 attached to the  
20 base 128 to form a head disk assembly (HDA) chamber. The cover 130 comprises an inner  
21 surface 132 (see FIG. 3A) and an outer surface 134. As shown in FIG. 3A, the cover 130 further  
22 comprises a shroud 136 extending axially from the inner surface 132 into the HDA chamber  
23 substantially enveloping the periphery of the disk 122, including at least part 138 of the  
24 periphery coextensive with the actuator arm 126, to provide radial shrouding of the disk 122.

25 The shroud 136 may be realized using any suitable means for extending a radial shroud  
26 from the inner surface 132 of the cover 130 such that the periphery of the disk 122 is  
27 substantially enveloped (including gap 138). In one embodiment, the shroud 136 is a separate

1 piece adhered to the inner surface 132 of the cover 130; for example, the cover may comprises a  
2 flat piece of metal and the shroud 136 an injection molded piece of plastic. Alternatively, the  
3 cover 130 may be completely form molded including to form mold the shroud 136. With  
4 injection or form molding, no additional components are installed during manufacturing to  
5 provide shrouding in the gap 138, nor is it necessary to precisely machine any such components,  
6 as with the prior art disk drive disclosed in U.S. patent No. 5,898,545 to Schirle.

7 FIG. 3B shows an alternative embodiment of a cover 130a for an HDA which, in addition  
8 to the shroud 136, further comprises a substantially C-shaped depression 140 positioned  
9 substantially concentric over the disk 122. The C-shaped depression 140 reduces the air volume  
10 in the HDA chamber relative to the surface of the disk 122 which provides axial shrouding in  
11 addition to the radial shrouding provided by shroud 136. The C-shaped depression 140  
12 comprises depression extremities 142 and 144 that are formed in the cover 130a in such an  
13 orientation that, when the cover 130a is attached to the base 128, depression extremity 142 lies  
14 on one side of the actuator arm 126, and depression extremity 144 lies on the other side of the  
15 actuator arm 126. In this way, the depression 140 can be brought closer to disk 122, thereby  
16 displacing a larger volume of air while providing a gap to allow the actuator arm 126 to rotate  
17 and actuate the head 124 over the surface of the disk 122. As shown in FIG. 4, in one  
18 embodiment an outer layer 146 may be adhered to the cover 130a using a visco damping  
19 adhesive which attenuates acoustic noise emanating from the disk drive 120. And in yet another  
20 embodiment, a damping material (e.g., a metal having a tuned mass or compressed acoustic  
21 foam) is placed within the cavity formed by the C-shaped depression 140 and the outer layer 144  
22 which further attenuates the acoustic noise.

23 A method of manufacturing a disk drive with improved shrouding according to one  
24 embodiment of the present invention comprises the step of forming a shroud 136 extending  
25 axially from an inner surface 132 of a cover 130. A head disk assembly (HDA) is disposed into a  
26 base 128 of an HDA chamber, wherein the HDA comprises a disk 122, a head 124, an actuator  
27 arm 126 for actuating the head 124 radially over disk 122, and a spindle motor for rotating the

1 disk 122. The cover 130 is attached to the base 128 of the HDA chamber such that the shroud  
2 136 substantially envelopes the periphery of the disk 122, including at least part 138 of the  
3 periphery coextensive with the actuator arm 126, to provide radial shrouding of the disk 122. In  
4 one embodiment in which the shroud 136 is a separate piece, the method further comprises the  
5 step of adhering the shroud 136 to the inner surface 132 of the cover 130. In another  
6 embodiment, the method further comprises the step of form molding the cover 130; wherein the  
7 form molded cover 130 comprises the shroud 136. In yet another embodiment, the method  
8 further comprises the step of forming a substantially C-shaped depression 140 in the cover 130,  
9 the C-shaped depression 140 positioned substantially concentric over the disk 122 to provide  
10 axial shrouding.

11 Because the cover 130 is attached to the base 128 of the HDA chamber after placing the  
12 actuator arm 126 in gap 138 and rotating the actuator arm 126 to position the head 124 over the  
13 disk 122, the shroud 136 integrated with the cover 130 can extend into the gap 138 providing  
14 additional shrouding over the prior art disk drive of FIG. 1.